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Abstract

IN-PILE EXPERIMENTAL EQUIPMENT FOR BR2

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A large part of this work has been performed by the Association C.E.N.-EURATOM for the exploitation of the BR2 reactor and its auxiliary installations (Contract N°006-60-5/BRAB).

The paper gives a description of some of the principal in-pile irradiation devices for use in the high flux research reactor BR2; points of discussion deal mainly with the application of engineering principles to the problems encountered in submitting both fissile and non-fissile materials to a neutron flux.

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Several loops and rigs with or without instrumentation are reviewed.

A sodium cooled loop for the test irradiation of specimen fast reactor fuel pins in a fast neutron flux has been designed for the French Commissariat à l'Energie Atomique. The loop is intended for the study of the behaviour of the fuel pins under conditions as near as possible to those in a sodium cooled fast reactor. The characteristics which have been reproduced, are the mass flow rate of sodium, the neutron spectrum and the specific power output (2 kW/cm^3). On the other hand, much thought had to be given to the problems of the safety aspects, the operation and the availability to other users of the BR2 reactor while the loop is in-pile.

A paricular point of interest of the loop is that the primary sodium circuit is very compact ; it is contained in a pressure tube which constitutes the in-pile section and therefore does not extend outside the BR2 reactor pressure vessel.

To obtain the required neutron spectrum, two annular neutron filters, one of cadmium and one of boron carbide, placed in series "filter out" the low energy neutrons. To achieve the required neutron flux the fuel elements of the BR2 core will entirely surround the in-pile section of the loop.

Design and manufacturing problems connected with the loading of the loop had to be solved; these problems arise not only from the loop itself but from the difficulties associated with the accomodation of the loop in the reactor. The paper examines the range of the problems met to operate the loop in-pile.

A gas cooled loop designed for the O.E.C.D. Dragon project has been put into operation to irradiate in a high flux reactor samples of graphite of a type to be used in a high temperature gas cooled reactor.

The aim of the research programme is to irradiate the graphite in a high neutron flux in an extended temperature range. A very important section of the ancillary equipment of the loop is the helium purification system because a great amount of research interest lies in the phenomenon of mass transfer of the graphite to the helium and the influence on this of the impurities conveyed by the helium.

The loop includes several novel features notably those associated with the design and manufacture of the in-pile section.

The paper examines the problems of building and operating the loop.

A gas cooled loop, principally for testing fuel elements for gas cooled reactors is designed for SIEMENS (Erlangen) by S.E.R.A.I. One may check, for instance, the dimensional stability of the fuel and the variation of thermal conductivity under irradiation, study the diffusion of fission products and the influence of thermal cycling, find out the life-time (maximum burn-up of the elements), as well as the heat flux corresponding to the partial or total melting of the fuel, to the growth of the grains and to the failure of the cladding. The experiments may also yield interesting data on the corrosion behaviour of the samples as a function of coolant composition.

Besides testing fuel elements, the flexibility of the loop is such as to allow other experiments amongst which the examination of different structural or control materials under irradiation, as well as investigation on coolant chemistry. The study of the graphite-CO_2 reaction at high temperature and under irradiation seems to be particularly important.

The loop may also help to check efficient detection systems to indicate contamination of reactor circuits. Decontamination methods and general equipment behaviour can also be investigated.

The general loop lay-out and the design of its different sections are discussed in detail.

Other experimental equipment is either under consideration or developed for the BR2 reactor. Each experiment presents some particular problems which have to be solved before it can go in-pile. Initially each experiment is examined from the nuclear and thermal characteristics standpoints before a complete design study is started. Eventually nuclear and thermal calculations are verified by measurements on models in the BRO2 and the BR2, for fine and coarse reactivity calibration, and by doing heat balances out-of-pile.

Among the rigs designed attention is drawn to a boiling water capsule in which knowledge of the heat flux from a fuel pin may be obtained.

The paper gives a review of some particular applications of rigs and also describes improvements and modifications carried out on the BR2 fuel elements to provide better irradiation facilities.